MAGNETISM, MARINER'S COMPASS
AND ELECTRIC TELEGRAPH-1853

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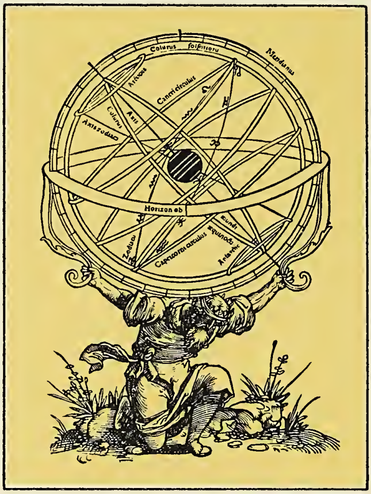

MAGNETISM;

A SKETCH OF THE HISTORY AND PRINCIPLES OF THE SCIENCE AND ITS
VARIOUS USEFUL APPLICATIONS, INCLUDING THOSE OF THE

MARINER'S COMPASS AND ELECTRIC TELEGRAPH:

A

LECTURE

DELIVERED AT THE

HATFIELD MUTUAL IMPROVEMENT SOCIETY,

JANUARY 31ST, 1853,

BY

G. E. DERING, ESQ.,

OF LOCKLEYS.

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As the following sketch was intended to be essentially elementary, and confined to the first principles of Magnetical science,—it is feared that even the tyro may find it insufficient to supply the information he is in search of. To any person desirous to follow up the subject, no work can be better recommended than that of Sir W. Snow Harris, published in Weale's series of rudimentary scientific works. I must acknowledge my obligation for some facts connected with the HISTORY *of the Mariner's Compass to this work; also to Professor Barlow's Treatise on Magnetism, in the Encyclopedia Metropolitana; Dr. Roget's treatise on the same subject in the Library of Useful Knowledge; "Electricity and Magnetism," in Lardner's Cyclopedia; Sturgeon's "Annals of Electricity;" Tomlinson's "Manual of Natural Philosophy;" "Lorimer on the Magnetic Needle;" besides works of older date, which need not be enumerated, and various scientific periodicals. The principles of Dia-Magnetism, which has now become almost a distinct science, and the beautiful results of Faraday's recent investigations upon the "lines of magnetic force," are not touched upon, as my object was to induce an interest in the science through its general facts and their applications, rather than to pursue the branches of at present purely scientific interest into which it divides itself.*

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LECTURE ON MAGNETISM,

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I have the greatest pleasure this evening in complying with a request that I would address to the Hatfield Literary Institute a lecture on some subject in Natural Philosophy. I have chosen the subject of Magnetism because it is a science of which the leading phenomena may be illustrated by the most simple experiments, and I wished to employ only such experiments as may be repeated by any one who has once seen them with apparatus of his own construction, without the use of complicated philosophical instruments.

Some persons may, perhaps, imagine that Magnetism is a dull and abstruse subject, unsuited for popular illustration; I can only state my conviction that if the beautiful laws on which magnetic phenomena depend prove uninteresting, the cause of this will be found to rest with the demonstrator, and not in the subject itself. The history of Magnetism is I think interesting as illustrative of the gradual manner of the development of most of the leading sciences,

> "——— slowly, slowly, creeping on from point to point."

Of the practical utility of the science under consideration there can be no question, when I remind you that it is the foundation of the grandest discovery ever made in the annals of Natural Philosophy,—I may call it the most important of all human inventions,—the Mariner's Compass. What advance would civilization and commerce have made in the world without the discovery of that mysterious property of nature which animates the compass? causing it to point to certain fixed quarters of the earth, and "thus enabling the mariner however distant from land, amidst cloudy skies or in the darkest nights, to steer his course with certainty, and traverse in all directions the wide expanses of ocean which separate the countries and continents of our globe." Without this guide no voyage could be undertaken with safety beyond sight of land, except beneath an unclouded sky; one single minute's obscuration of the heavenly bodies leaving the unhappy vessel at the mercy of the waves, utterly without the means of direction. The Electric Telegraph is another application of Magnetism which

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appears likely in its effects upon the condition of mankind almost to vie in importance with the compass itself.

Before noticing particularly these applications of Magnetism, I must call your attention to magnetic phenomena in general: commencing with the loadstone, originally supposed to be the only source of the mysterious power in question, and briefly tracing the history of the science from its earliest development. In the very first place it is necessary that I should explain one point on which some persons may be misinformed, by observing that the magnets commonly sold under the name of loadstones do not in reality consist of this material, being nothing more than steel bars rubbed with the natural loadstone in a particular manner, to be hereafter described, and thus endowed with the magnetic virtue. The real loadstone is rarely met with except in the cabinet of the mineralogist. It is an ore of iron, a combination of iron and oxygen, and is found in the earth in various parts of the world. India, China, Arabia, Norway and Sweden, Germany, Macedonia, England, all afford specimens slightly different in colour and texture, and in the amount of magnetic virtue which they possess. The ancients considered that there were five distinct kinds of loadstone,—the Ethiopian, the Magnesian, the Bœotic, the Alexandrian, and the Natolian. The peculiar property of attracting iron and ferruginous matters, which distinguishes this material from all others, appears to have been noticed in very early times; reference being made to it in the most ancient Chinese manuscripts and in the writings of the Greek, Roman, and Egyptian philosophers,—Homer, Thales, Pythagoras, Plato, Aristotle, Theophrastus, Lucretius, Cicero, Pliny, Ptolemy, Hippocrates, Democratus, Leucippus, Epicurus, and many others. Thales supposed the material to be possessed of a soul or animating spirit, and Plato who called it the "stone of Hercules," said that the cause of its attraction was divine. Lucretius attributed its attractive power to a property of the magnetic effluvium to drive the air out of the space between the magnet and any piece of iron applied to it, and by thus producing a vacuum to cause the iron to be pressed towards the loadstone. The lines in which he expresses this idea are thus translated by Dr. Busby:—

> "Soon shall we trace by what mysterious laws,
> What secret energy, what latent cause,
> Steel, the strong magnet, actuates and draws.
> First, then, my loved illustrious Memnon, know,
> Ceaseless effluvia from the magnet flow—
> Effluvia whose superior powers expel
> The air that lies between the stone and steel.
> A vacuum formed, the steely atoms fly
> In a linked train, and all the void supply."

Various names have been given at different times to the mineral we are considering, and the phenomena dependent upon it. The most ancient appears to be that of the "Magnet" or *μάγνης* in Greek, said by some to have been derived from Magnesia, a province of Lydia, where the material was found in great abundance. This account of the origin of the name seems to be confirmed by the lines of Lucretius—

> "Quod superest agere incipiam quo fœdere fiat
> Natura lapis hic ut ferrum ducere possit,
> Quem magneta vocant patrio in nomine Graii,
> Magnetum, quia sit patriis in finibus ortus."

Other persons affirm that the name was derived from one Magnus, a shepherd of Mount Ida, of whom it is related by Pliny and others, that whilst attending his flocks he laid his crook down upon a rock and fell asleep. On awaking and attempting to take up the crook he found it strongly adhering to the rock. This fact, it is said, he communicated to some philosophers, who tried further experiments with pieces of the same rock, and called it "Magnes," after the name of the discoverer. The name loadstone is derived from the Icelandic "leiderstein," the *leading stone,* after the Saxon "lœdan" *to lead.* The Chinese call the stone "thsu-chi" or love-stone, from its apparent affection for iron. The Sanscrit name "ayaskánta" has a similar meaning, and also the French "l'aimant." So universal has the knowledge been of the attractive properties of this stone from the earliest ages, that in almost every language of the world it has some fanciful or characteristic name.

Up to this point we have vaguely considered the natural loadstone as possessing the property of attracting iron and ferruginous matters. But it will be found that any lump of this material, whatever its shape, does not possess the property to an equal degree at all parts of its surface. In general the force will be found to be nearly equally concentrated at two points opposite to one another. These points, which have received the name of "poles," may readily be detected by sprinkling over the stone fine iron filings, which will adhere in greatest quantities at the parts of greatest attractive force. It is advisable to shape the stone to an elongated figure, having the two poles for its extremities; we then have it in that form in which, after the knowledge of its attraction for iron, it was experimented upon by the early philosophers, and the other remarkable properties, which it possesses, discovered. The effect nearest akin to that of the simple attraction of the loadstone for iron is, that it imparts to a piece of iron in contact with it the power of attracting other iron; thus, one piece of iron supported by the stone is capable of supporting another by its extremities, this one another, and so on until the weight becomes so great as to detach the whole from the magnet. The experiment is best shown by small rings of iron, which, when thus united, have the appearance of a suspended chain. This property, which has received the name of "induction," was very early observed. It is referred to by the poet Lucretius in the lines which have been thus translated:—

> "Its viewless potent virtues" (that is, of the loadstone) "men surprize—
> Its strange effects thay view with wondering eyes,
> When, without aid of hinges, links, or springs,
> A pendant chain we hold of steely rings
> Dropt from the stone—the stone the binding source—
> Ring cleaves to ring and owns magnetic force :
> Those held superior, those below maintain,
> Circle 'neath circle downward draws in vain,
> Whilst free in air disports the oscillating chain."

It is important to observe that the moment we remove the loadstone the power of the links to attract one another ceases, but it is restored by the approach of the loadstone. It is not necessary that there should be actual contact between the loadstone and iron; the mere vicinity of the stone being sufficient to induce in iron its own remarkable properties.

We now come to an important division of the science under consideration, namely, the power of the loadstone to impart its own virtues *permanently* to steel or very hard iron. If we simply lay down a steel bar upon a loadstone parallel with it and then withdraw it, we shall find it possessed in a small degree of the magnetic power, as may be proved by its attraction for iron filings; the parts of greatest attractive force being those which were in contact with the poles of the loadstone. If we stroke the steel bar lengthwise with one pole of the loadstone, always passing it from end to end in the same direction, we shall find the bar operated upon possessed of a very high degree of magnetic force, greater in some cases than the loadstone which produced it. It would naturally be supposed that the loadstone we employ must lose a large amount of its power by imparting so much to another body; but, remarkable as it may appear, we invariably find that it is rather stronger after the operation than before,—"an example to which we find no complete analogy, except," it has been beautifully said, "in the human mind; which, like the magnet, in imparting to others its own stores does not lose the possession of them itself, but, on the contrary, improves them." A magnet formed in the manner I have described possesses in all respects the properties of the natural loadstone; it can therefore be employed to induce magnetism in other steel bars, and so magnets may be multiplied *ad infinitum* without recourse being had to the loadstone, which is not near so convenient for experimental purposes as the steel bars or "artificial magnets," as they are termed. A very convenient form of magnet is that known as the "horse-shoe" shape, in which the two extremities or poles are brought near together, and thus concentrate their force upon any object brought within their influence. The combined attractive force of the two poles thus arranged is much more than double that of either of them singly, as will be found by applying a piece of iron and computing the force required to withdraw it. It is hardly necessary to remark that the red varnish usually applied to steel magnets is simply for the purpose of preventing the unpleasant contact of metal with the hands. Small horse-shoe magnets are very useful to watchmakers to pick up steel screws dropped upon the floor, and I believe ladies occasionally make use of them to recover lost needles—it is only necessary for such purposes to attach the magnet to a piece of string and thus drag it about at random upon the floor in the manner of fishing, when it will seize upon anything it meets with of iron or steel much quicker than it could be detected by the eye. I am informed that at the present moment immense numbers of these "toy-magnets" as they have been named are being shipped for Australia; I have made many enquiries to find out for what use they are intended but without success. One application of magnets of this description, which until lately I thought was quite out of date in these days of Mechanics' Institutes, I must notice: Only a week ago I was told in a shop in London where large quantities are sold, that a person had just purchased a "threepenny magnet" for the purpose of curing rheumatism, "having been told by the doctor that it was the best remedy." Whether the mere possession of the magical piece of steel was supposed to act as a charm to drive away the malady, or in what manner it was to be applied, I could not ascertain. The property of a loadstone to induce magnetic power in steel and of one steel bar to communicate the virtue to another, appears not to have been understood by the early experimenters in the science, or only to a very small extent; their observations were therefore limited to the natural loadstone, and its effect upon iron. The gradual diminution of a magnet's power from the extremities towards the centre, at which point the force is absolutely nothing, has not yet been noticed. It may be beautifully illustrated by placing flat upou a magnet a sheet of white paper, and then sprinkling upon the paper iron filings from some height above. The filings arrange themselves in thick clusters about the poles, and in gradually diminished quantities towards the centre, where there is no influence exerted. The experiment is assisted by gently tapping the paper, which for the moment separates the particles from it, and thus removing the slight friction of contact leaves them entirely free to obey the magnetic influence. In some cases they arrange themselves in the most elegant curves extending from one pole to the other, and between corresponding points of the two halves into which the magnet may be supposed to be divided by a line drawn across the centre. M. d'Haldat has given considerable attention to these "magnetic curves," and has subjected them to geometrical investigation with a view to elucidate some of the mysteries of magnetic science; the results he has arrived at are most interesting. Whatever shaped magnet be employed in the experiment the effects are nearly similar. It might be imagined that the interposed sheet of paper would in some degree interrupt the magnetic power, and it is a common mistake to suppose that "non-conductors" of electricity are also non-conductors of the magnetic power. But it must be received as an ascertained fact that no substance in nature, except such as are susceptible of being themselves acted upon by the magnet, in the slightest degree intercepts the subtle influence. The only two substances besides iron and its compounds that are with certainty proved to be attracted by the magnet are the metals nickel and cobalt: in both the effect is very feeble. We may notice in this place that elevations of temperature exert a powerful influence on all magnetic bodies, whether susceptible of permanent or only of temporary magnetism. As the temperature is increased all the magnetic effects become gradually weaker and weaker, and at a white heat entirely cease. Thus by being heated throughout the strongest magnet can be deprived of its power; but it may be restored in the usual manner when cold, provided the steel be brought to the proper temper. There are various methods of applying magnets to induce the property in other bars, besides that which has been described of stroking from end to end. But, as the principle of all of them is alike, it is unnecessary to detail the manipulation, which will be found in most treatises on the subject. Some of the methods that have been proposed produce a much more powerful effect than the plan of simply stroking with one pole. Small magnets are proportionately much more powerful than those of larger dimensions. It is said that Sir ISAAC NEWTON wore in a finger-ring a magnet weighing only three grains, which would lift 760 grains, *i.e.*, 250 times its own weight.

We must next consider the mutual influence which magnets exert upon one another. For this purpose let a loadstone, or an ordinary bar-magnet, be suspended by a string attached to its centre, equally balanced, and free to move in all directions: now apply to one of its poles, first one and then the other pole of another magnet held in the hand, and it will be found that one of these poles *attracts*, and the other *repels* from it, the pole to which it is presented; but the pole which attracts either of the poles of the suspended magnet will be found to repel the opposite pole, and *vice versâ*. Thus we find that the two poles of any magnet possess distinct properties in relation to other magnets; though in relation to iron there is no difference perceptible, either pole attracting with equal force. If we take any number of magnets, and make a distinguishing mark on that pole of each which exerts similar influence either of attraction or repulsion upon the same pole of the magnet suspended for trial, we shall find upon trying the effect of these magnets on one another that the results follow the invariable law that *between like poles there is repulsion, between unlike, attraction.* The effect of repulsion appears to have been observed early in the history of the science, though imperfectly understood. In Pliny we read that "there is a kind of stone in Ethiopia which will not abide iron, but repulses and driveth iron away from it." Upon the combined effects of magnetic attraction and repulsion depend the magnetic toys so familiar in every nursery: Sagacious swans which when floating in water approach a piece of bread held to them at the end of a magnetic wand, but move themselves off when the opposite extremity is pointed at them; fishes which unfortunately seldom escape the hook; and other ingenious applications of the same principle.

We now come to the most important of all the properties of the magnet; namely, that of *direction,* or the indication of north and south. The effect may be shown by simply attaching a piece of fine thread to the centre of a magnet, or suspending it in any other manner quite free to move in all directions. We perceive that it at once places itself in a certain definite position, and even if it be forcibly moved into any other position, when set free it returns again after a few oscillations to that which it had of itself assumed. This position is north and south, or to speak correctly, within twenty-five degrees of the actual line of north and south. Upon this remarkable property of the magnet the Mariner's Compass depends: how simple a principle to produce results of such incomparable importance! Who the discoverer of the directive virtue of the magnet was, we know not; but we can in some degree realise the feelings with which he must for the first time have observed it obey with certainty the unknown influence. Many discussions have taken place at various times as to what country the honour is due to of having first employed the magnetic *needle,* as it is called when supported so as to show the effect of *direction,* in navigation or in land journeys. The Chinese affirm that the compass was known to them from all antiquity; and, certainly there appear to be obscure allusions to it in the earliest literature of that mysterious people. Du Halde, in his "General History of the Chinese Monarchy," speaking of the Emperor Hoangti, when he gave battle to Tchi Yeou, says, "He perceiving that thick fogs saved the enemy from his pursuit, and that the soldiers rambled out of the way and lost the course of the wind, made a card which showed the four cardinal points; by this method he overtook Tchi Yeou, made him prisoner, and put him to death. Some say there were engraved in his car, on a plate, the characters of a rat and a horse, and underneath was placed a needle to determine the four parts of the world." In another part of the same book, speaking of certain ambassadors, he says, "After they had their audience of leave, in order to return to their own country, Tcheou Kong gave them an instrument which on one side pointed towards the north, and on the opposite side towards the south, to direct them better on their way home than they had been directed in coming to China. The instrument was called Tchi-Nan, which is the same name as the Chinese now give the sea compass; and this circumstance has given occasion to think that Tcheou Kong was the inventor of the compass. This happened in the twenty-second cycle, more than 1040 years before the birth of Christ." If the compass was really known at this period it is difficult to imagine why its use for sea voyages should have failed to spread itself westward until two thousand years later. About the year 121 of our era, under the Emperor Nghanti, of the dynasty of Han, there appeared a valuable Chinese dictionary in which the character of "tseu" (magnet) is defined as "the name of a stone with which the needle is directed." In an old letter from China we find an interesting illustration of the mystery that was attached to the formation of compass needles, as follows:—"To give polarity to a needle.—Take of cinnabar, realgar, and steel filings, equal quantities reduced to a fine powder. Mix them up with blood from a cock's crest. Cover the needles with the mixture; wrap them in paper and put them into an oven, under which you will keep up a charcoal fire for seven days and nights. This done, wrap them and carry them next your skin for three days; they will then serve for the mariner's compass." It is certain that the compass was unknown to the philosophers of Greece and Rome. Some have supposed that Solomon was acquainted with it, and that by its use he was enabled to send his mariners to Peru, then called Parvaim and Ophir.* The earliest positive account of the compass being in use in Europe is in an old French poem called "*La Bible Guiot.*" This poem forms the first article of a curious unpublished quarto manuscript on vellum of the 13th century, now in the Royal Library of Paris. The following is a literal translation of the remarkable passage in question. The French from which it is taken appears to have suffered much from the carelessness of transcribers.

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* See Pineda *de rebus Solomonis,* L. iv., c. 15.

"This same (the pole) star does not move, (and)
They (the mariners) have an art which cannot deceive,
By the virtue of the magnet,—
An ugly brownish stone
To which iron adheres of its own accord.
Then they look for the right point,
And when they have touched a needle (on it)
And fixed it on a bit of straw
Lengthwise in the middle, without more,
And the straw keeps it above ;
Then the point turns just
Against the star undoubtedly.
When the night is dark and gloomy,
That you can see neither star nor moon,
Then they bring a light to the needle ;
Can they not then assure themselves
Of the situation of the star towards the point (of the needle) ?
By this the mariner is enabled
To keep the proper course ;
This is an art which cannot deceive."

From this quotation, written about the close of the 12th century, there can be no doubt that the mariner's compass was in use at that period. Its construction appears to have been very rough, and the mode of suspending the needle similar to that employed by the Chinese, namely, to attach it to a piece of cork, wood, *straw*, or some other light body floating in a vessel of water. This sounds a rude method of suspension compared with the delicate agate cap and steel point arrangement of the present day; nevertheless, the principle of the two is identical, as well as that of suspending the needle by a thread attached to the centre,—the object of all being to allow it freedom to arrange itself in the position which its magnetic properties would cause it to assume. Professor Hansteen, in his "Inquiries concerning the Magnetism of the Earth," quotes some expressions of an Icelandic historian, which seem to prove that the directive property of the natural loadstone was known in Europe nearly a century before the date of the poem just quoted. "Are Frode," he says, "by whom the account of the discovery of Iceland was written, mentions that Floke Vilgerderson, a renowned 'viking' or pirate, the third discoverer of the island, departed from Rogaland, in Norway, to seek Gadersholm (Iceland), some time in the year 868. He took with him three ravens to send as guides; and in order to consecrate them to his purpose, he offered up a great sacrifice in Smörsund, where his ship lay ready to sail. *For in those times seamen had no loadstones in the northern countries.* According to the testimony of Snorro Sturleson, Are Frode was born in the year 1068; this account was therefore probably written about the end of the 11th century." Cardinal Jacques de Vitri, in his history of Jerusalem, published about the year 1200, speaks of the magnetic needle as indispensable to those who travelled by sea. Dr. Gilbert, of Colchester, in his famous Latin treatise on magnetism, published in the year 1600, the first work on the subject published in this country, affirms that Paulus Venetus brought the compass from China to Italy in 1260. It is said that the Syrian captains employed floating loadstones for guiding their vessels in dark nights, and that as early as the 13th century they magnetised steel needles for this purpose. Flavius Blond affirms that in or about the year 1302, one John Goia, a noble citizen of Amanphi, a town of Principato in the kingdom of Naples, first discovered the mariner's compass; and to confirm this he quotes a line from Antony of Palermo, recorded by the Neapolitan historians—

> "Primo dedit nautis usum magnetis Amanphi."

The arms of the territory of Principato have, it seems, ever since been a mariner's compass. It is generally supposed that Goia learnt the use of the compass in the East, and that being the first Italian who ventured to trust to its guidance on the sea, he thus erroneously received the credit of being the inventor. There are proofs of the compass having been known to the northern nations before the 14th century; for in 1266, on the death of the Swedish Count Byrgeris, Sturla celebrated his memory in a poem consisting of twelve verses; and when he attended the King to the boundaries of the kingdom, he produced this poem in an assembly of the States; and as a reward for his genius he was presented with a mariner's compass.* It is certain that Vasco de Gama, the Portuguese navigator, used the compass in his voyage to India in 1497. Ludi Vertomanus asserts that about 1500 he saw a pilot in the East Indies direct his course by a magnetic needle like those now in use. We are told that the East Indians in the 16th century, and prior to that time, suspended the magnetic needle on a point in a china dish filled with water, so that the needle gently floated: the bottom of the dish being marked with cross lines to denote the principal winds.

We have thus traced the history of the compass from the earliest times up to its general adoption by the trading nations of the world. The first grand result of its efficacy must here be noticed, namely, the discovery of America by Columbus in 1492. It was on this voyage that one important fact connected with the compass was first observed, namely, that the needle does not at all parts of the world point to precisely the same points, but that there is a slight difference in its direction in different latitudes. This effect is quite distinct from the *declination* of the needle which has been before alluded to, namely, the difference of a few degrees between the actual line of North and South, or the axis of the earth, and that in which the needle places itself. The *declination* was discovered 200 years before the time of Columbus. An interesting account of the observation made by Columbus is given in Irving's "Life and Voyages of Columbus," as follows:—"On the 13th of September he discovered about nightfall that the needle instead of pointing to the north star, varied about half a point, or between five and six degrees to the north-west, and still more on the following morning. Struck with this circumstance, he observed it attentively for three days, and found that the variation increased as he advanced. He made no mention of this phenomenon, knowing how ready his people were to take alarm; but it soon attracted the attention of the pilots, and filled them with consternation. It seemed as if the laws of nature were changing as they advanced, and that they were entering into another world, subject to unknown influences. They apprehended that the compass was about to lose its mysterious virtues; and without this guide, what was to become of them in a vast and trackless ocean? Columbus tasked his science and ingenuity for reasons with which to allay their terrors. He told them that the direction of the needle was not to the polar star, but to some fixed and invisible point; that the variation was not caused by any failing in the compass, which, like the heavenly bodies, had its changes and revolutions, and every day described a circle round the pole. The high opinion which the pilots entertained of Columbus as a profound astronomer gave weight to his theory, and their alarm subsided." We all know the result of Columbus' voyage, and many a "Galileo of new words below" since his time has probably been conducted to the fulfilment of his hopes by the same simple confidence which he evinced in the stability of Nature's laws and the efficacy of his Compass,—

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* See "Torfæus (Thormodus) *Historia rerum Norvegicarum*," tom. iv., p. 345.

> "That power which, like a potent spirit, guides
> The sea-wide wanderers over distant tides,
> Inspiring confidence where'er they roam,
> By indicating still the pathway HOME."

It may be, perhaps, considered that I have entered too minutely into the history and use of the compass; but it must, I think, be admitted that it is impossible to overrate the importance of this application of the science under consideration. To conclude this division of the subject, I will quote the remarks upon it of one of the earliest English writers on magnetism—William Barlowe, of Winchester—whose treatise was published in the year 1618. I will read the passage in the author's own quaint language, from an actual copy of the work: it is after speaking of some details in the construction of the instrument, he says,—"Vpon the consideration "hereof, my workmen of Winchester, minding to present *Prince Henry* with a rare instrument, contrived "an *Æquinoctiall Diall* and an Inclinatory Instrument "both in one, and one needle to serue very well both "these turnes. Herein now appeareth the wonderfull "wisdom of our God, in limiting his times and seasons, "for the reuealing of these wonderfull properties for "the vse of men, in this poore stone, namely that above "2000 yeeres after that it was knowen and wondred "at in the world for lifting up of iron (for it was an "antiquity in *Platoes* time), the vse of the Horizontall "needle was knowen, in common use, scant 200 yeeres "agone; and very few yeeres since (yea scant as yet) "the inclinatory is in any common vse: and who is "there that can behold and consider both these vses, "viz., both to shew the quarters of the world (as East, "West, North, and South, &c.), and also the latitude of "the place; to know both these in any place of the "world, bee the heauens neuer so much ouercast with "clowds, who is he, I say, that can behold these two "admirable and precious vses performed, even with the "turning of an hand, the which neither the Grecian "philosophers, nor the fine-witted Romans, nor the "Persian Magi, nor the Indian Gymnosophists could "finde out with all their skill and cunning, but he must "needs say with the Kingly Prophet, 'O Lord, our "Lord, how great is thy name through all the earth, "who hast set thy glory above the heavens'?" At the end of this work is inserted a letter to the author from Dr. Gilbert of Colchester, whom I have already referred to as the earliest writer on the subject of magnetism in this country. The letter is interesting as affording a good idea of the opinion which the writer entertained of Barlowe's talents in this branch of science:—It is addressed; "To the Worshipfull my "good friend, Mr. William Barlowe at Eaton by Winchester,—Recommendations with many thanks for all "your paines and courtesies, for your diligence and "enquiring and finding diuers good secrets, I pray proceed with double capping your Loadstone you speake "of, I shall be glad to see you, as you write, as any "man. I will have any leasure, if it were a month, "to conferre with you, you have shewed mee more, and "brought more light than any man hath done. Sir, I "will commend you to my *L* of *Effingham*, there is "heere a wise learned man, a secretary of *Venice*, he "came sent by that State, and was honourably received "by her Maiesty, he brought me a lattin letter from a "gentle-man, of *Venice* that is very well learned, whose "name is *Iohannes Franciscus Sagredus,* he is a great "magneticall man, and writeth that hee hath conferred "with diuers learned men of *Venice,* and with the "Readers of *Padua,* and reporteth wonderfull liking of "my booke, you shall have a coppy of the letter; Sir, "I purpose to adioyne an appendix of six or eight "sheets of paper to my booke after a while, I am in "hand with it of some new inuentions, and I would "have some of your experiments, in your name and "inuention put into it, if you please that you may be "knowen for an augmenter of that arte. So for this "time in haste I take my leaue the xiiijth of February, "your very loueing friend, *W. Gilbert.*" The title of Barlowe's work is quaint and curious; viz., "Magneticall "Advertisements: or divers pertinent obseruations, and "approued experiments, concerning the natures and "properties of the Loadstone. Uery pleasant for knowledge, and most needfull for practice, of trauelling, "or framing of Instruments fit for Trauellers both by "Sea and Land." The dedication commences as follows:—"To the right Worshipfvll, discreet, and learned "Gentleman, Sir Dvdley Digges *Knight.* Sir, the "nature, powerfullnesse, and strange properties of the "*loadstone* are such, that the more they are known, the "more they are iustly admired in their most liuely "expressing that infinite power, and goodnes of our "God, who hath created so precious a Iewell for the "profitable vse of man, and for the enlarging and "setting forth of his owne glory. Into the search of "which admirable and secret vertues my selfe by the "space of these forty yeeres, haue somewhat entred "(as my leasure and occasions would serue, and at by "times) partly by reading other mens writings, and "partly by my owne industrie and practize: whereby "what I have collected, and found, this little treatise "will shew. Which, whether it be anything or "nothing, I do referre vnto iudicious *Readers* con-"sideration, but in special to your fauourable construc-"tion and good acceptance." In the "preface to the reader" he describes the loadstone as "a base, con-"temptible and dead creature as it seemeth to be, and "yet filled with such excellent and wonderfull vertue, "that all the Gemms of the world have not the like; "neither if it were wanting could supply the want "thereof or countervaile the benefit that it bringeth to "the life of man." The whole of this is I think interesting as showing the importance that was attached to the properties of the loadstone in the earlier periods of its history; and also the zeal with which the experimenters of those days applied themselves to the subject we are considering. But I was fortunate enough a short time since to meet with a still greater curiosity than Barlowe's work, in the shape of one of the original copies of the first treatise ever published on the subject; viz., the Latin letter of Petrus Peregrinus "de Magnete" written as long ago as the year 1269. A manuscript copy of this letter is to be seen in the University of Leyden: and Cavallo, in his treatise on magnetism, published fifty years ago,—in which he gives some quotations, with a translation of them, from a copy he had procured of this manuscript,—states that the letter was never published. But in this he was mistaken, for here certainly is a copy of it, published at Augsburg in the year 1558. It is a literary curiosity as well as *magnetically* so. Mention is made in it of much supposed to have been undiscovered at the time it was written. It is rather remarkable that the author of this letter is erroneously called Peter *Adsiger* both in Cavallo's work and in every other I have seen in which it is referred to. This mistake appears to have originated in a wrong transcription, at some early period, of the title of the letter, which is, "Epistola Petri Peregrini de Maricourt, *ad Syger*um de Foncaucourt militem, de magnete." In Cavallo's work and most others reference is made to a letter by Petrus Peregrinus as a distinct manuscript; but this is evidently erroneous. I also have here a copy of the work of Dr. Gilbert "de magnete," which is interesting as being the first work on the subject published in this country, and valuable for the information it contains.

The *dip* of the needle is the next property to be considered. It may be observed in a very simple manner: If we take a steel needle, not magnetised, and mount it upon a horizontal axis, so that it can assume either the horizontal or vertical position, or any intermediate angle; and if we then balance it so accurately that it will rest in equilibrium in any position in which we place it, we shall find on magnetising the needle that it is no longer indifferent as to position in the vertical plane; but that it at once assumes a decided position, which in this latitude is an angle amounting to about 70° divergence from the horizontal. At the North Pole the position is perpendicular, with what is improperly called the north end of the needle downwards; at the South Pole it is also perpendicular with the south (or proper north) end downwards: and at the equator the position is exactly horizontal.

We have now I think considered the whole of the elementary phenomena of magnetism; most of which may be classed under four distinct heads,—

1st. The properties of magnets (both natural and artificial) in relation to iron and the other temporarily magnetic metals.

2nd. The property of magnets to induce permanent magnetism in steel bars.

3rd. The influence of magnets upon one another.

4th. The property of freely suspended magnets to assume certain definite positions in relation to the earth.

All attempts at theoretical explanation have been avoided, as they would at once open too wide a field of conjecture to be advantageously entered upon on the present occasion. In conclusion, I propose briefly to notice a few of the practical applications of the science of magnetism.

One of the most recent uses to which magnets have been applied in the arts is in the manufacture of paper. Most persons must have observed on the leaves of books, more particularly those of an old date, certain offensive marks like spots of "ironmould." If we examine one of these blemishes, we shall, at the centre of it, find a minute particle of iron, the oxide of which gradually formed by the natural moisture of the paper, has spread around to perhaps the size of sixpence or even larger. These iron particles which come from the machines employed, and cannot be avoided, are now removed from the paper by magnets whilst it is fluid in the state of pulp. In many of the large manufactories of Birmingham and elsewhere powerful magnets have been recently brought into use for the purpose of effecting the separation of the iron and brass filings produced in the work carried on: the filings of both metals are afterwards applied to various useful purposes for which they would be utterly useless when mingled together as they come from the workshop: there is probably no other means by which they could be separated. In some manufactories on the continent, and I believe also in this country, where heavy iron and steel work is carried on, magnets are kept always at hand for the purpose of extracting the particles of the metal which frequently find their way into the workmen's eyes. The "needle-grinder's mask" is the next application of magnetism to be noticed; and there are lessons to be learned from the history of this invention. Any one who has visited the districts in which the needle manufacture is carried on needs not be reminded of the deadly effect upon the workmen of the process they are engaged in: Inhaling all day long from their earliest years an atmosphere impregnated with the steel dust given off from millions of needles in the process of sharpening—(one man alone can point ten thousand in an hour)—before the age of twenty their health is utterly ruined, at thirty they are emaciated old men, and death comes proportionately early. A remedy was provided, the simple plan that each man should wear whilst at work a kind of respirator of steel wire, so acted upon by magnets as, by the power of attraction, to intercept the fatal dust in its passage to the lungs. (Sir John Herschel remarks that "by these masks the air is not merely *strained* but *searched* in its passage through them, and each obnoxious atom arrested and removed.") Glad, one imagines they would be, to take advantage of the discovery; but, one and all, they refused to adopt it.

They are intelligent men, and cannot but be convinced of the efficacy of the invention, for, at the end of each day's work, the magnets are found to be covered with steel dust, which otherwise must have passed into the lungs; but still they will not adopt it, *because* at present their wages are very high, proportionally to the mischief they are exposed to, or, we may say, to the short duration of their lives, and they apprehend reduced pay if their employment should be made a healthy one. The utility of the compass needle in all surveying operations, every one must be acquainted with, as it forms an essential part of the theodolite. To the miner penetrating the recesses of the earth, and in all tunneling operations it is almost as indispensable as to the seaman. A recent application of magnetism is, to the separation of iron ore from foreign matters, on the principle described in reference to the filings of metals.

One more application of the science, I must notice, which appears likely to be almost as world-wide in its effects as the mariner's compass—I mean the Electric Telegraph. Although the vital principle of this invention is electricity, without magnetism it could not exist. To understand the general principles of the simplest and most perfect form of telegraph, it is only necessary to be aware of one of the effects of the electric current from a galvanic battery; namely, to produce magnetism in any bar of iron round which it is caused to circulate through a metallic wire; which magnetism ceases, the moment that the current ceases to flow. The direction of the north and south poles of the bar depends on the direction in which the current is passed, and may, therefore, be varied at pleasure. In the form of telegraph to which I refer, two of these magnets are so arranged in relation to a freely suspended magnetic needle as to cause it to assume either of two distinct positions, according to the direction of the current. On the cessation of the current it returns to the neutral position. Thus it will be evident that, if we place an arrangement of this kind at York, for instance, and send the current of electricity to it along the wires from London, we have the power of conveying two definite signals, which may be repeated, and various combinations of them formed, to express the letters of the alphabet or any other signs agreed upon. The passage of the electric fluid along the wire to the distant point is so rapid (280,000 miles per second) that for all practical purposes it may be considered as instantaneous.

The power of an electric current to induce magnetism in iron is well exemplified by a bar bent into the horse-shoe form, and wound round with a piece of wire previously covered with gutta percha or some other non-conductor of electricity in order to prevent contact between the separate turns of the wire, or between it and the iron: on applying an iron bar or "keeper" to the extremities of the horse-shoe bar it will be found that the moment a current of electricity is passed through the wire, strong magnetism is excited; but it ceases as soon as communication with the galvanic battery is cut off. The power thus produced is so enormous when large batteries are employed, and at the same time so easily directed and regulated, that it seems probable that it will ere long supersede steam both for stationary purposes and also for land and water locomotion. This result must follow the invention of any cheap galvanic battery that will compete with steam in point of working expense: neither noise nor smoke will then annoy the railway traveller, and we shall hear of no more boiler explosions! I have good reason for thinking that we shall soon witness some very important advances in this direction.

STEPHEN AUSTIN, PRINTER, HERTFORD.